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Risk Factors for Postpartum Emergency Department Visits in an Urban Population

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Abstract

Objectives To identify risk factors associated with urban postpartum emergency department utilization. *Methods* This case–control study included 100 matched pairs of postpartum women who had delivered at a large, integrated urban medical system in Bronx, New York, in 2012–2013, with the cases having had an emergency department visit within 42 days of delivery. The cases, identified utilizing administrative and billing data, were matched 1:1 with controls by labor unit, delivery mode and date, excluding nonviable pregnancies. The controls did not have a known postpartum emergency department visit. Variables were abstracted from administrative data and chart review, and included demographics, antenatal/intrapartum/postpartum complications and neonatal intensive care unit admission. Factors associated with puerperal emergency department use were identified via univariate and multivariable analyses. *Results* Following conditional logistic regression, primiparity [54% vs. 32%, aOR 5.91, 95% CI 2.34–14.91], public insurance [70% vs. 56%, aOR 4.22, 95% CI 1.60–11.12], weekend delivery [30% vs. 26%, aOR 7.61, 95% CI 1.15–52.43] and delivery-related complications [47% vs. 28%, aOR 2.95, 95% CI 1.16–7.51] were associated with an increased risk of postpartum emergency department use, while women of younger ages (17–24 years old) were less likely to have postpartum emergency department use [aOR 0.23, 95% CI 0.07–0.74]. Univariate analysis of individual events within the composite variables showed an association between gestational hypertension/pre-eclampsia and postpartum emergency department use [28% vs. 13% OR 2.60, 95% CI 1.26–5.39]. Psychiatric history, social instability, preterm delivery/neonatal intensive care unit admission, pre-existing medical/antepartum conditions and prolonged postpartum stay were not associated. *Conclusions for Practice* Delivery-related complications, delivery timing, and certain sociodemographic factors are identifiable risk factors for increased postpartum emergency department utilization. These may be targeted for development of interventions improving puerperal care and potentially preventing emergency department visits, which are costly to the health system and disruptive to the lives of women and their families.

Keywords Maternal morbidity · Postpartum emergency department use · Postpartum period · Risk factors for postpartum emergency department use

Significance

What is already known on this subject? More than four million women in the United States give birth each year, with almost 5% visiting the emergency department during the

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puerperium (Russo et al. 2006; Clark et al. 2010). Despite the associated morbidity and costs, limited analyses have examined the risk factors associated with urgent postpartum issues in urban patient populations. *What this study adds* This study identifies both clinical and sociodemographic risk factors for increased postpartum emergency department utilization, which may be targeted for development of interventions to improve puerperal care and potentially prevent costly emergency department visits.

Introduction

More than four million women in the United States give birth each year (Russo et al. 2006). Most of these women are scheduled for a single postpartum office visit 6 weeks after delivery, yet almost 5% visit the emergency department (ED) within that 6-week period prior to their postpartum visit (Clark et al. 2010). Of those postpartum patients, more than 75% on average are treated and discharged home (Brousseau et al. 2016). Indeed, the women who ultimately are re-admitted represent a small portion of those presenting to the ED for acute care. Yet, most of the published studies regarding acute care utilization in the postpartum period focus only on hospital readmission data rather than the full complement of postpartum ED visits when evaluating maternal morbidity or measures of hospital quality (Clark et al. 2010; Clapp et al. 2016; Belfort et al. 2010).

Postpartum ED visits result from a wide variety of medical concerns, involving varying degrees of urgency (Clark et al. 2010; Brousseau et al. 2016; Gussman et al. 2015). Presentation to the ED may represent an urgent postpartum complication (such as endometritis), an exacerbated non-obstetric condition (such as asthma), or even inadequate outpatient access for non-routine care needs. Regardless of reason, the impact of postpartum ED visits is broad-reaching, extending beyond the morbidity to the woman, the family unit and even the health system at-large. The economic burden to the medical system could be substantial when considering the national annual volume of deliveries and trends toward payment bundling to include post-discharge emergency care or hospital readmissions (Gussman et al. 2015; Colla et al. 2012; Weinick et al. 2010; Orszag 2009; Jencks et al. 2009; Health Affairs Health Policy Brief 2015; New York Department of Health 2015).

Despite the associated health, societal, and financial costs, and the national and local recognition of the need to prioritize and address issues in the puerperium (e.g. Healthy People 2020 and state Medicaid assessments) (Callaghan et al. 2012; D'Alton 2010; Britten 1995), limited analyses have examined the risk factors for postpartum ED visits (Clark et al. 2010), aside from delivery route. Based on clinical experience and prior studies looking at hospital readmission

during the postpartum period (Sharvit et al. 2014; Belfort et al. 2010; Hamilton et al. 2002; Harris et al. 2015), we hypothesized that complications during the intrapartum and postpartum periods (including peripartum infection, hypertensive diseases and postpartum hemorrhage) would be major risk factors for an increased likelihood of postpartum ED visits. The objective of this project was to identify demographic and clinical factors that increase the risk for postpartum ED utilization in an urban obstetric population. Identifying women with an increased likelihood for postpartum ED utilization ultimately may aid in the design, timing and implementation of targeted interventions to reduce the need for use of post-delivery acute care facilities.

Methods

We performed a case–control study analyzing the association of different socio-demographic and clinical factors with an increased likelihood of puerperal ED use. Institutional review board (IRB) approval was obtained prior to study commencement and this study therefore was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Due to the retrospective nature of data collection performed by chart review, IRB exempted the study from requiring informed consent.

The study was performed at a large, integrated medical system located in Bronx, New York with multiple hospitals that include three EDs and two labor and delivery units, serving an urban population with known health and resource disparities. Approximately 6400 deliveries occur annually in this system, with a 9.2% postpartum ED visit incidence rate. The two labor and delivery units are equivalently equipped and staffed by employed faculty who provide care in work-hour shifts (weekday 8 am–5 pm, weeknight 5 pm–8 am, weekend 9 am–9 am the next day). Care provided is determined by each attending provider but guided by system-wide policies, including management of intrapartum processes (such as treatment of chorioamnionitis or surgical antibiotic prophylaxis) and of postpartum patients with any hypertensive disease (pre-existing or pregnancy-related) who are offered home nursing services or an additional 1-week post-delivery outpatient clinic visit for blood pressure checks. The labor and delivery suites are each associated with triage units that offer emergent diagnostic care for pregnant women only; any hospital-based care needed during the postpartum period is evaluated initially in the ED. Our institution supports an integrated system of clinical and administrative hospital-based electronic records.

Our baseline rate of both intrapartum and postpartum complications that we hypothesized to be major risk factors for increased likelihood of postpartum ED visits is

approximately 25% of all deliveries. We presumed a 2.5-fold increase in the occurrence of such events among the postpartum women who presented to the ED. Considering the historical baseline prevalence at our institution and findings from prior studies of such delivery complications (Callaghan et al. 2010, 2012; Hutcheon et al. 2011; Ananth et al. 2013; Gibbs and Duff 1991; Getahun et al. 2010), we calculated the minimum sample size to be 86 matched pairs, using an alpha of 0.05, a power of 80% and a matching ratio of 1:1 (Machin et al. 1997).

We identified our cases from a list of women who had delivered in 2012 and 2013 and had visited the ED during their 42-day postpartum period. These cases were compiled using Clinical Looking Glass® (CLG; Emerging Health Information Technology, Yonkers, NY), a software application developed to query electronic information across hospital clinical and administrative databases. Women who had delivered nonviable infants were excluded. We selected 100 cases from the list in consecutive order based on date of discharge from initial delivery admission, oversampling beyond the calculated sample size needed in order to account for the potential of missing or incomplete data. The controls were patients who had delivered and had not visited the ED within the 6-week postpartum period. Because delivery mode is a known clinical risk factor for postpartum ED utilization, with cesarean delivery being associated with an increased risk of 1.5–3.2 (Clark et al. 2010; Gussman et al. 2015) and because physician- or hospital-level differences may have influenced postpartum ED visit rates, cases were matched 1:1 with controls who experienced the same mode of delivery both performed by the same provider and occurring closest to the time of the index case delivery. We identified controls from labor unit delivery logs that are separately maintained on each labor unit.

We performed data abstraction for each patient using multiple electronic medical record sources, including the administrative, prenatal outpatient, hospital and ED settings. We collected more than 70 variables describing psychosocial conditions, demographics, clinical data and delivery-related conditions and events selected based on clinical experience and prior literature regarding postpartum re-admissions (Belfort et al. 2010; Clapp et al. 2016; Hamilton et al. 2002; Russo et al. 2006; Sharvit et al. 2014).

Sociodemographic data included age (re-coded into a categorical variable based on quartile distribution: 17–24 years, 25–28 years, 29–33 years, and 34 years and older, with the quartile of '29–33 years' serving as the reference group), insurance type [public (including both Medicaid and dual Medicaid/Medicare coverage) or private], and race/ethnicity (self-reported by the patient). Socioeconomic status (SES) was reported in CLG as a Z-score based on the patient's address and was evaluated using six variables (household income, value of housing units, rental income, education, the percentage of adults who completed college, and employment). The SES variable was categorized as either above or below the state average. Marital status was collapsed into two categories: single vs. married/committed relationship.

Clinical data collected included parity (nulliparous vs. multiparous), BMI (mg/kg^2) as a continuous variable, along with the dichotomous variable of obesity (BMI > 30 mg/kg^2), presence of preterm delivery prior to 37 weeks for the current pregnancy, timing of delivery and hospital discharge day (weekday vs. weekend day; in our hospital system, the number and distribution of staff working during the weekend is less than during the week). 'Psychiatric issues' included self-reported history or electronic medical record documentation of formally diagnosed disorders (e.g. anxiety, depression, or other psychiatric condition) that are known to be associated with an increased risk of postpartum mental illness, regardless of prior or current medication use or therapy (Barker et al. 2016). The 'social instability' composite included any event or condition for which hospital-based social workers would assess the patient per departmental protocol and included such situations as reported drug use/abuse, the presence of unstable housing, scant prenatal care, or history of intimate partner violence. Due to the high risk of our patient population and the catchment area we serve, it is standard in our system to screen on all obstetric admissions for the potential psychiatric or social concerns that comprise these variables. The 'NICU infant' variable indicates infant admission to the neonatal intensive care unit (NICU). This variable was collected as a proxy for both potentially unrecognized maternal medical complications and exacerbation of previously recognized complications by the emotional and physical distress caused by pair separation. 'Prolonged postpartum stay' was defined as a hospital discharge occurring later than the usual stay for our institutions: 2 days after a vaginal delivery and 3–4 days following a cesarean delivery. Clinical data also included pre-pregnancy medical history, pregnancy-related clinical diagnoses, and significant clinical events or complications. We coded the data as dichotomous variables, indicating the presence of such a condition, but did not account for the severity or the complexity of the medical illness or event.

To further organize these clinical variables, we recognized two ways of subcategorization: by system (i.e. infection, hypertensive or cardiovascular disease, endocrine, etc.) or by temporal pattern (i.e. pre-existing, antenatal, labor-related, etc.). Because variables identified within distinct time periods of peripartum care likely parallel the temporal patterns of how outpatient prenatal and inpatient labor care are segmented, potentially suggesting opportunities to improve care in the different settings (e.g. during prenatal care, on labor and delivery, during the postpartum period), we chose to organize this part of the analysis by temporal pattern. These temporally-organized composite clinical

variables reflect clinical conditions or complications that occurred at different times during the pregnancy-related care: "pre-existing conditions", "antepartum issues", and "delivery issues". These composite variables were dichotomous in nature and were considered positive if at least one of the potential conditions existed. The composite variable 'pre-existing conditions' included chronic hypertension, pregestational diabetes and asthma. The 'antepartum issues' variable included gestational hypertension, gestational diabetes and group B beta streptococcus (GBS) colonization. The 'delivery issues' composite encompassed any complication during the intrapartum or immediate postpartum period occurring during the index hospitalization, such as the development of gestational hypertension or preeclampsia (as defined prior to the publication of the 2013 American College of Obstetricians and Gynecologists Task Force on Hypertension in Pregnancy report), chorioamnionitis or endometritis, postpartum hemorrhage, wound infection, or a third or fourth degree perineal laceration.

We determined the incidence of different indications for those patients who had visited the ED during the 42-day postpartum period. Reasons for visiting the ED were identified based on the primary indication for the ED visit as listed in administrative data, classified based on the Clinical Classical Scheme (Elixhauser et al. 2017) and further informed by the ICD-9 diagnostic codes that had been assigned at the time of ED evaluation. These indications were then organized into groupings of similar pathophysiologic conditions and further stratified by relatedness to pregnancy and by urgency in a strategy modified from that employed by Clark et al. (2010).

We performed univariate analyses to assess association with postpartum ED visits using Wilcoxon signed rank test for continuous variables and McNemar's tests for categorical variables. We performed further univariate subanalyses on the individual components of the composite temporal clinical variables. Additionally, we evaluated for interactions between certain demographic and clinical variables based on an a priori risk and informed by the univariate results.

We developed an a priori model for multivariable analysis based on clinical experience and prior literature; this model was then informed by the univariate results. We preformed conditional logistic regression that was further refined in a stepwise manner with a p-value less than or equal to 0.25 for entry into the model and a p-value less than or equal to 0.30 to remain in the model. The impact of interaction terms on the refined model of main effects was then evaluated using the partial F-test based on a more stringent adjusted p-value of 0.00625, as calculated using the Bonferroni correction. All other p-values were two-sided, with a value less than 0.05 being considered significant.

All analyses were generated using SAS software (Version 9.4, SAS Institute Inc, Cary, NC).

Results

One hundred matched pairs were identified and analyzed. Fifty-one pairs delivered vaginally and 49 pairs were delivered by cesarean. Two-thirds delivered at the larger of the two delivery units. The distribution of patient demographics, psychosocial history, and other clinical information by case vs. control, with odds ratios demonstrating associations with postpartum ED visits, are shown in Table 1. Women who presented to the ED during the postpartum period were significantly more likely to be publicly insured [70% vs. 56%, Odds Ratio (OR) = 1.88, 95% Confidence Interval (CI) = 1.02–3.44], to be primiparous [54% vs. 32%, OR 2.08, 95% CI 1.23–3.57], and to have experienced a delivery-related issue [47% vs. 28%, OR 2.27, 95% CI 1.24–4.16]. The majority of women in both groups were single, with no significant differences between groups in mean age, race/ethnicity, reported social instability, past medical or psychiatric history, or current pregnancy issues. Additionally, most women in both groups were obese, with no significant differences in median body mass index values. Both groups had similar incidences of preterm deliveries and infant admissions to the NICU. There were no significant differences between groups regarding delivery or hospital discharge on a weekend day or regarding the length of postpartum hospital stay. Analysis of interactions showed a significant interaction between marital status and age, with older single women more likely to have presented to the ED in the postpartum period [single women ≥ 34 years old: OR 8.97, 95% CI 1.66–48.34]. To illustrate the modifying effect of marital status on age, we stratified each age quartile into single and married women and depicted the crude odds ratio for likelihood for having a postpartum ED visit among each subgroup (Fig. 1).

In order to evaluate the impact of individual labor issues, the primary outcome composite variable 'delivery issues' was subdivided into its component events (Table 2). Initially, we looked at the overall occurrence of events in the intrapartum or the immediate postpartum periods, and found that both composite variables, 'intrapartum issue' [31% vs. 18%, OR 1.93, 95% CI 1.01–3.68] and 'immediate postpartum issue' [26% vs. 11%, OR 2.67, 95% CI 1.24–5.74], were significantly associated with postpartum ED visits on univariate analysis. Analyzing each isolated event comprising the aforementioned composite variables showed that only an intrapartum or postpartum diagnosis of gestational hypertension or pre-eclampsia significantly increased a woman's likelihood of a postpartum ED visit, while chorioamnionitis or endometritis, third or fourth degree perineal lacerations, postpartum hemorrhage, any postpartum infection, or other intrapartum or postpartum events had no significant association.

Table 1 Distribution of sociodemographic and clinical characteristics among 100 case–control pairs

	Total n (%)	Case %	Control %	Crude OR	95% CI
N	200	100	100		
Median age in years (IQR)[a]	28.0 (24.0, 33.0)	29.0 (25.0, 34.5)	28.0 (23.0, 33.0)		
Age by quartiles[b]					
17–24 years	56 (28.0%)	23	33	0.81	(0.39, 1.70)
25–28 years	47 (23.5%)	26	21	1.29	(0.63, 2.65)
29–33 years (ref)	51 (25.5%)	24	27	1.00	–
≥ 34 years	46 (23.0%)	27	19	1.50	(0.68, 3.31)
Race/ethnicity (self-reported)[b]					
White, non-Hispanic	11 (5.5%)	4	7	1.00	–
Hispanic	51 (25.5%)	28	23	2.05	(0.50, 10.01)
Black, non-Hispanic	57 (28.5%)	23	34	1.11	(0.24, 5.74)
Other	58 (29.0%)	34	24	2.56	(0.55, 13.90)
No response	23 (11.5%)	11	12	1.81	(0.34, 11.00)
Preferred language[b]					
English	176 (88%)	88	88	1.00	–
Spanish	17 (8.5%)	8	9	0.61	(0.07, 0.79)
Other	7 (3.5%)	4	3	0.77	(0.12, 0.73)
Marital status: single (missing = 1)[b]	126 (63.3%)	64	62	1.05	(0.58, 1.88)
Public insurance[b]	126 (63%)	70	56	1.88	(1.02, 3.44)
Below state average SES	185 (92.5%)	94	91	1.50	(0.53, 4.21)
Primiparity[b]	86 (43.0%)	54	32	2.08	(1.23, 3.57)
Preterm delivery during current pregnancy[b]	19 (9.5%)	13	16	0.79	(0.36, 1.73)
Delivery on weekend[b]	56 (28%)	30	26	2.33	(0.60, 9.02)
Discharge on weekend[b]	62 (31.0%)	32	30	1.25	(0.49, 3.17)
Prolonged postpartum stay[b,c]	17 (8.5%)	11	6	1.94	(0.69, 5.46)
Social instability[b] (scant prenatal care, illicit drug use, unstable housing, intimate partner violence)	7 (3.5%)	2	5	0.40	(0.08, 2.06)
Psychiatric issues[b] (anxiety, depression, other psychiatric disorder)	25 (12.5%)	11	14	0.75	(0.32, 1.78)
Median BMI, kg/m² (IQR)[a]	31.7 (27.6, 37.3)	31.7 (27.4, 37.4)	31.7 (28.0, 37.3)	1.01	(0.97, 1.05)
Obese (BMI ≥ 30)[b]	122 (61.0%)	62	60	1.09	(0.62, 1.92)
Preexisting conditions[b] (chronic HTN, diabetes, asthma)	144 (72.0%)	74	70	1.24	(0.65, 2.34)
Antepartum issue[b] (gestational HTN, gestational diabetes, group B beta streptococcus colonization)	57 (28.5%)	31	26	1.28	(0.69, 2.37)
Delivery issue[b] (preeclampsia, gestational HTN, chorioamnionitis/endometritis, postpartum hemorrhage, wound infection, third or fourth degree perineal laceration)	75 (37.5%)	47	28	2.27	(1.24, 4.16)
NICU infant[b]	30 (15.0%)	16	14	1.18	(0.53, 2.64)

SES socioeconomic status; BMI, Body mass index, reported in kg/m²; HTN, hypertension; NICU, Neonatal Intensive Care Unit

Data are % for binary and multilevel categorical levels, unless specified otherwise. For multilevel variables, % are provided for distribution across variable levels

[a]Based on Wilcoxon signed rank test

[b]Based on McNemar's χ^2 test

[c]Prolonged postpartum stay as defined as longer than 2 days following a vaginal delivery and longer than 4 days following cesarean section

Table 3 details indications for postpartum ED visits (Table 3). Almost three-fourths of the visits (72%) were for conditions that are potentially attributable to the pregnancy or delivery. Overall, slightly more than half of the ED visits (52%) were categorized as non-urgent and most of these patients (96%) were not admitted. The most common indications for postpartum ED visits included hypertensive

Fig. 1 Interaction effect between maternal age and marital status on likelihood of a postpartum ED visit. The interaction term between marital status and maternal age in quartiles was significantly associated with increased likelihood of a postpartum ED visit among unmarried women aged 34 years or older. The crude odds ratio of this modifying effect is depicted by age quartile and stratified into single and married status. *ED* emergency department, *OR* odds ratio, *CI* confidence interval

Age of postpartum women by quartiles
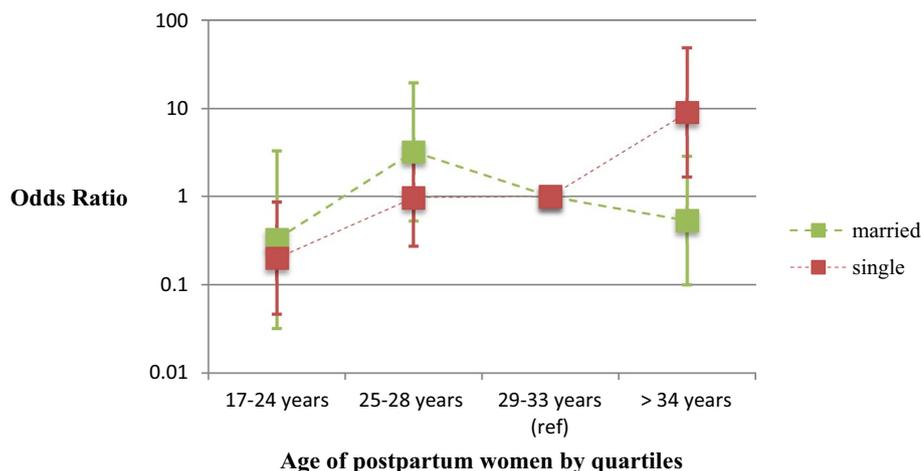
	17 – 24 years	25 – 28 years	29 – 33 years	≥ 34 years
single	0.2 (0.05, 0.87)	0.97 (0.27, 3.46)	ref	8.97 (1.66, 48.34)
married	0.33 (0.30, 3.31)	3.22 (0.53, 19.46)	ref	0.54 (0.10, 2.87)

Table 2 Unadjusted sub-analysis[a] of likelihood of a postpartum ED visit in the setting the occurrence of a delivery event, a composite of issues occurring in the intrapartum and immediate postpartum periods, further delineated into the individual events

	Total n (%)	Case %	Control %	OR[a]	95% CI
N	200	100	100		
Delivery event	75 (37.5%)	47	28	2.28	(1.27, 4.10)
Intrapartum issue	51 (25.5%)	31	18	1.93	(1.01, 3.68)
Immediate postpartum issue	37 (18.5%)	26	11	2.67	(1.24, 5.74)
Chorioamnionitis/endometritis	9 (4.5%)	5	4	1.25	(0.34, 4.66)
Gestational HTN/pre-eclampsia	41 (20.5%)	28	13	2.60	(1.26, 5.39)
3rd/4th degree laceration	6 (3.0%)	4	2	2.00	(0.37, 10.92)
Any postpartum infection	12 (6.0%)	8	4	2.09	(0.61, 7.17)
Postpartum hemorrhage	15 (7.5%)	10	5	2.00	(0.68, 5.85)
Other intrapartum issue	6 (3.0%)	4	2	2.00	(0.37, 10.92)
Other postpartum issue	6 (3.0%)	4	2	2.00	(0.37, 10.92)

OR odds ratio, *CI* confidence interval, *HTN* hypertension

[a]Based on McNemar's χ^2 test

disease or pre-eclampsia (13%), abdominal pain (12%), and non-specific fever (11%).

Following multivariable analyses with conditional logistic regression, the likelihood of having a postpartum ED visit was found to be significantly associated with being primiparous [aOR 5.91, 95% CI 2.34–14.91], having public insurance [aOR 4.22, 95% CI 1.60–11.12], experiencing a delivery-related adverse event during the intrapartum or immediate postpartum period [aOR 2.95, 95% CI 1.16–7.51], or having delivered over a weekend [aOR 7.61, 95% CI 1.15–52.43], and inversely associated with younger age (17–24 years old) [aOR 0.23, 95% CI 0.07–0.74] (Table 4). While the interaction term between marital status

and age was itself significant, its inclusion in the model of main effects did not significant improve the fit of the model, with a partial F test showing p = 0.007.

Discussion

Despite the potential costs to the patient, her family and the medical system, there are limited data examining associated sociodemographic and clinical risk factors for postpartum ED visits. Prior studies of ED utilization in the postpartum period were predominantly descriptive, based on administrative data, and focused mostly on the timing and indications

Table 3 Primary indications for postpartum ED visits stratified by relationship to pregnancy and urgency

Urgent	Frequency	Non-urgent	Frequency
Pregnancy-related (n = 72)			
Vaginal bleeding/hemorrhage	4	Urinary tract infection	1
Hypertension/pre-eclampsia	13	Abdominal pain, unspecified further	12
Endometritis	5	Edema without hypertension	1
Mastitis	1	Dressing change, suture removal	4
Wound infection/separation	8	Fever	11
Other surgical complication	3	Breast engorgement	1
Heart failure/pulmonary edema/ fluid overload	1	Noninflammatory disease, vagina	4
		Episiotomy concern	2
		Bell's palsy/facial weakness	1
Total	35	Total	37
Non-pregnancy-related (n = 28)			
Trauma	3	Headache without hypertension	6
Cholecystitis	2	Non-obstetric infection	1
Chest pain, cardiac event	4	Other medical diagnoses	6
Seizure without hypertension	1	Skin condition/allergic reaction	2
Other urgent issues	3		
Total	13	Total	15

Table 4 Multivariable regression model for increased likelihood of postpartum ED visit

Patient characteristics	aOR	95% CI
Age: 17–24 years	0.23	(0.07, 0.74)
25–28 years	1.23	(0.50, 3.00)
29–33 years (ref.)	1.00	–
≥ 34 years	2.60	(0.90, 7.51)
Marital status (ref: single)	1.17	(0.53, 2.58)
Primiparous	5.27	(2.18, 12.74)
Preterm delivery	0.40	(0.14, 1.11)
Public insurance	3.24	(1.40, 7.48)
Preexisting conditions	1.70	(0.72, 3.98)
Delivery issue	2.38	(1.03, 5.51)
Delivery on weekend	5.70	(1.03, 31.47)

OR odds ratio, *CI* confidence interval

Reference level is the unlisted level for binary variables and as noted for multilevel variables

Based on conditional multivariable logistic regression in a stepwise fashion

Full model included: Age by quantile, marital status, Race/Ethnicity, primiparity, preterm delivery, public insurance, pre-existing conditions, antepartum issues, delivery issues, delivery on a weekend, discharge on a weekend

for presentation to the ED, with women who had undergone cesarean deliveries being more likely to use the ED (Clark et al. 2010; Gussman et al. 2015). Our results showed an increased likelihood of ED visits by women who were primiparous, had public insurance, had a weekend delivery, or

experienced a delivery-related complication, independent of delivery mode and setting, while younger age was protective. Identifying these risk factors may allow for recognition of women at increased risk for postpartum ED use even prior to their discharge from their delivery hospital stay, with development of targeted interventions to reduce emergency department visits during the postpartum period.

As we had hypothesized, women with an intrapartum or immediate postpartum complication, particularly gestational hypertension/pre-eclampsia during the delivery admission, were associated with increased puerperal ED utilization. Delivery complications, even if addressed adequately prior to discharge, may increase the risk for future morbid events. With pregnancy-related hypertensive disease, which can linger after delivery and may take up to 2 years to resolve (Berks et al. 2009), opportunities for intervention may arise prior to a patient presenting to the ED for acute care services. Additionally, while non-hypertensive complications, such as infection or postpartum hemorrhage also occurred more frequently in women who subsequently utilized the ED, they were not statistically significant when individually evaluated. These individual complications may be short-lived compared to hypertensive disease, and may not adversely affect post-discharge maternal health. Alternatively, our study may not be powered to see a significant difference.

In addition to clinical risk factors, we identified sociodemographic factors that were significantly associated with increased likelihood of postpartum ED visits, including having public insurance or being primiparous. Several reasons could explain the association of public insurance with an

increased likelihood of ED use. Public insurance may be related to poorer health status or decreased access to medical care. Although there were no significant associations between the presence of pre-existing medical conditions and postpartum ED utilization, women with public insurance may have overall worse baseline health, resulting in impaired healing and increased risk for more complex illnesses and complications. Our study only quantified the presence of pre-existing disease, but did not qualify the degree of severity. While the absolute presence of pre-existing disease may not have differed, the patients who went to the ED may have had more complex and severe disease. Additionally, women with public insurance may experience barriers to accessing outpatient care for unscheduled visits, leading to the ED being a point-of-entry for care regardless of clinical urgency.

Sociodemographic factors significantly associated with a decreased likelihood of a postpartum ED visit included women who were younger (17–24 years old). Previously, studies have showed that younger women have significantly decreased risks of obstetrics complications such as preeclampsia, cesarean delivery, operative vaginal delivery and post-partum hemorrhage (de Vienne et al. 2009). These findings are likely due in part to younger women having fewer chronic age-associated medical conditions prior to pregnancy, such as chronic hypertension and pregestational diabetes, ultimately decreasing the risk of pregnancy-related complications and subsequently their seeking of acute medical care.

Other significant sociodemographic or clinical systems risk factors associated with postpartum ED use may be related to knowledge deficits, inadequate health education, or insufficient social support. Women who are primiparous and those who have a weekend delivery may be more likely to seek ED care for potentially outpatient-amenable issues because of inaccurate expectations regarding normal postpartum events from lack of prior experience or inadequate education while being inpatient on a weekend when decreased staff is available. The knowledge deficit, coupled with inadequate communication during the discharge process and potentially insufficient social support outside the hospital, may lead to unrecognized abnormal findings or unwarranted concerns about normal findings. The resultant delays in seeking care for clinically significant problems may increase ED utilization.

Our findings in postpartum women mirror some of those findings seen in the general population of patients readmitted within 30 days of discharge. As in our study, the complexity of the hospital course and insurance status and type are associated with the increased risk of having ED visits (Friedmann et al. 2001; Wang et al. 2016). However, unlike our study, these other studies also showed a significant impact of mental health/psychiatric history and pre-existing medical conditions. Interventions that have been implemented in the Medicare population have shown

that increased care coordination or use of a predictive tool to target higher-risk populations significantly decreased the number of 30-day post-discharge ED visits and readmissions (Koehler et al. 2009; Karam et al. 2015).

Our study evaluated all postpartum ED visits, regardless of indication or urgency. While postpartum ED use may be appropriate in certain situations, in other instances it may represent potentially preventable maternal morbidity, inefficient healthcare resource allocation and unnecessary costs to the system and society. Notably, women who present with non-obstetric related issues or potentially out-patient amenable issues may represent different populations and warrant further study. Potential interventions for the obstetric population may include increased access to care through earlier postnatal checkups or visiting nursing services. Although prior randomized controlled trials of earlier postpartum clinic visits (Gunn et al. 1998) and home nurse visits (Lieu et al. 2000) among low risk patients showed no significant differences in health outcomes, postpartum ED visits or re-hospitalizations, such care pathways directed at higher risk patients might promptly identify evolving complications or reassure the worried-well and prevent ED visits. Further study of both interventions, including their optimal timing, is required.

Our study was novel in our inclusion of multiple clinical and sociodemographic characteristics obtained through extensive chart review extending beyond administrative records of ICD9 and CPT codes, but was limited by its retrospective nature and study size. The quality of data abstracted from hospital records may have been variable due to inadvertent incomplete ascertainment of pertinent medical history at the time of admission for delivery, especially for women who received prenatal care outside of our institution and presented to us for delivery alone. Inclusion of such patients may have led to lack of recognition of potential clinical or demographic risk factors omitted in the condensed prenatal records or not endorsed by the patient on interview. The distribution of known missing data, though, was not significantly different between groups. Additionally, some women receiving ED care outside of our system could have been misclassified as controls, biasing our results towards the mean. Furthermore, our study was performed on an urban, at-risk population, which may limit its generalizability. Lastly, a lack of power may have resulted in failure to demonstrate the impact of less common events or diagnoses, as noted by the lack of significant statistical association with the likelihood of ED visits among the individual morbid events comprising the composite clinical variables. A post-hoc power analysis shows that at least an additional 375 matched pairs would need to be analyzed to evaluate effectively the potential impact of individual delivery-related disease states.

Despite the limitations, our study has identified important risk factors associated with postpartum ED utilization. This initial study will allow for a more in-depth investigation into factors influencing care seeking behaviors among the postpartum population obtaining ED care and identify opportunities to address them. With preemptive recognition of exacerbating situations or higher-risk subgroups during the prenatal period or prior to discharge from the delivery hospital stay, we may be able to apply targeted interventions and systems-level strategies to reduce postpartum ED visits that are costly to the health system and disruptive to the lives of women and their families.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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